

WHAT IS CLAIMED:

[0034] 1. An apparatus for processing a workpiece comprising:

a liquid supply source;

one or more liquid outlets disposed to apply liquid onto the workpiece;

5 a liquid flow line extending between the liquid supply source and the one
or more liquid outlets for carrying liquid to the liquid outlets;

at least one heater for heating the liquid before it is applied onto the
workpiece;

an ozone gas supply system which provides ozone gas around the
10 workpiece; and

a sonic energy source for introducing sonic energy to the workpiece.

[0035] 2. The apparatus of claim 1 further comprising a sonic energy conductor in
contact with the sonic energy source and in contact with the sonic energy source.

[0036] 3. The apparatus of claim 2 wherein the sonic energy conductor comprises
15 quartz, silicon, metal or a polymer.

[0037] 4. The apparatus of claim 1 with the sonic energy source associated with the
liquid outlets, to provide sonic energy to the workpiece via liquid moving out of the outlets and
onto the workpiece.

[0038] 5. The apparatus of claim 1 wherein the sonic energy source comprises a sonic transducer including a focusing chamber for concentrating sonic energy onto the workpiece.

[0039] 6. The apparatus of claim 1 where the liquid supply source comprises a
5 liquid reservoir, and where the heater heats the liquid in the reservoir.

[0040] 7. The apparatus of claim 1 where the liquid supply source includes a liquid selected from the group consisting of, ammonium hydroxide, sulfuric acid, hydrochloric acid, hydrofluoric acid, a surfactant, de-ionized water, and a combination thereof.

[0041] 8. The apparatus of claim 1 further comprising a chamber around the workpiece and with the ozone gas supply connected to the chamber to provide ozone gas around the workpiece in the chamber, with the ozone provided as a dry gas or in a liquid.

[0042] 9. The apparatus of claim 8 further comprising a re-circulation liquid line extending between the chamber and the liquid supply source.

[0043] 10. The apparatus of claim 8 further comprising a rotor assembly in the
15 chamber for rotating the workpiece.

[0044] 11. The apparatus of claim 1 where the liquid outlets comprise liquid nozzles for spraying the heated liquid onto the workpiece.

[0045] 12. The apparatus of claim 1 further including means for controlling the thickness of a layer of the liquid formed on the surface of the workpiece.

[0046] 13. The apparatus of claim 12 where the means for controlling comprises a liquid flow control system for controlling the flow of liquid onto the workpiece.

5 [0047] 14. The apparatus of claim 13 where the liquid flow control system includes spray nozzles.

[0048] 15. The apparatus of claim 12 where the means for controlling comprises a rotor for holding and rotating the workpiece.

[0049] 16. An apparatus for treating the surface of a workpiece comprising:
10 a liquid reservoir for holding a process liquid;
a process chamber;
a workpiece holder within the process chamber;
liquid spray nozzles within the process chamber disposed to spray liquid onto the workpiece held by the workpiece holder;

15 a liquid flow line extending between the liquid reservoir and the liquid spray nozzles;

an ozone generator for generating a supply of ozone;

one or more ozone supply lines extending from the ozone generator to the process chamber;

20 at least one heater for heating the process liquid; and

a sonic energy source on the workpiece holder for introducing sonic energy to the workpiece.

[0050] 17. The system of claim 16 where the workpiece support holds the workpiece in a horizontal orientation.

5 [0051] 18. The system of claim 16 further comprising a valve connecting to a spent liquid line extending from the process chamber, to the liquid reservoir, and to a drain, with the valve switchable between a first position, wherein spent liquid from the process chamber is directed back to the reservoir, and a second position, wherein spent liquid from the process chamber is directed to the drain.

10 [0052] 19. A method for processing a workpiece, comprising the steps of:
positioning the workpiece at least partially within a bath of liquid;
creating an ozone atmosphere above the surface of the bath of liquid;
applying sonic energy to the bath of liquid;
moving at least one of the workpiece and the surface of the bath of liquid,
15 to cause the surface of the liquid to move across the workpiece surface.

[0053] 20. The method of claim 19 wherein the workpiece is positioned within the bath of liquid by lowering the workpiece into the bath.

[0054] 21. The method of claim 19 wherein the workpiece is positioned within the bath by raising the surface of the liquid.

[0055] 22. The method of claim 19 with the workpiece fully submerged in the liquid, while sonic energy is applied.

[0056] 23. The method of claim 19 further comprising heating the liquid to a temperature above ambient.

5 [0057] 24. The method of claim 19 further comprising positioning the workpiece in a second bath, removing the workpiece from the second bath, and drying the workpiece.

[0058] 25. The method of claim 19 where the liquid comprises water.

[0059] 26. The method of claim 25 with the liquid further comprising a member selected from the group consisting of HF, HCl, $\text{NH}_4(\text{OH})$, NH_4F .

10 [0060] 27. The method of claim 19 where the ozone atmosphere is created above the surface of the liquid by injecting ozone gas above the surface of the liquid.

[0061] 28. The method of claim 19 where the ozone atmosphere is created above the liquid surface by bubbling ozone through the liquid.